

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXVII.

May 10, 1867.

No. 7.

REV. CHARLES PRITCHARD, President, in the Chair.

James Whatman Bosanquet, Esq., Claysmore, Enfield,
John Joynson, Esq., Waterloo, Liverpool,

were balloted for and duly elected Fellows of the Society.

On the Distribution of the Nebula in Space.

By Cleveland Abbe, Esq.

Those who realise the incompleteness of our knowledge of the positions and nature of the so-called Nebulae, and the illusory nature of any conclusions generalized from our scanty stock of facts, are agreed as to the need of more systematic, thorough observations of both celestial hemispheres. In view of the important additions to our knowledge of these bodies to be expected when the results of Lassell's observations at Malta are published, and when Grubb's 4-foot mirror, Cooke's 25-inch, and Clark's 18-inch objectives (combined with spectra analysis), have yielded us whatever revelations they have to make from their respective stations at Melbourne, Funchal, and Chicago, it might be expected that one would defer any speculations to a future time.

The publication in 1864 of Sir John Herschel's *General Catalogue of Nebulae and Clusters of Stars*, enabled me some two years ago to attempt to gain some knowledge of the laws of the apparent distribution of these bodies; some of the most obvious of which had been already indicated in the "Results

of Astronomical Observations made at the Cape of Good Hope." If the present Note be found to present nothing new to the generality of those conversant with this field of research, its results may still be worthy of notice as being drawn from the study of a larger number of objects and a more systematic classification of them than seems to have been made the basis of previous opinions.

The investigation of Sir John Herschel above mentioned treats of the distribution of 3812 Nebulæ and Clusters visible to the 18½-inch reflector, as mounted successively at Slough and at Feldhausen, and its accompanying plate exhibits the grouping of these objects in quadrilaterals whose sides are 1 hour in R.A. and 15° in N.P.D. The General Catalogue of 1864 contains 5079 numbers, of which several represent more than one object, but as several numbers have been perhaps intentionally omitted, we may consider this as being very nearly the number of objects catalogued.

In order to obtain merely a general view, all these objects were arranged in groups whose sides were 30^m in R.A. and 10° in N.P.D. The summation of these groups gave 5076 as the number of objects represented; the accidental errors that may have crept into the process are considered as insignificant. The positions of the *Via Lactea* and the *Nubeculæ* having been indicated by heavy lines enclosing the proper quadrangles, a careful scrutiny sufficed to show that the *Nubecula Major* (N.M.) and the *Nubecula Minor* (n.m.) are distinct groupings, independent of each other and isolated from the *Via Lactea* (V.L.) Neither are these to be considered as centres of condensation for the general system of objects represented, which, on the contrary, exhibit a very decidedly increasing condensation as we approach the poles of the *Via Lactea* (R.A. 0^h 47^m N.P.D. 64°, and R.A. 12^h 47^m N.P.D. 116°).

The paucity of Nebulæ and abundance of Clusters within the neighbourhood of the *Via Lactea* have been before noticed; but it suggested itself as a subject of inquiry whether or no the stellar nature of this band of light, as resulting from the studies of the Herschels and Struve, could not be further corroborated by the present investigation.

A second table, showing the distribution of the Clusters, was now prepared, in which a distinction was made between the ordinary clusters (Cl.) and the globular ones (⊕). 637 objects were here represented, and their condensation in the *Via Lactea* and the *Nubeculæ* became very obvious.

A third table was added showing the distribution of the resolved or resolvable Nebulæ (marked *r*, *rr*, *rrr*, in Sir John's Catalogue). In this table were included those globular clusters (⊕) marked *r*, *rr*, or *rrr*; these may, as a general rule, be considered as coming in respect to ease of resolvability between the ⊕ and the resolved or resolvable nebulæ; of the ordinary clusters (Cl.) only two are marked as *r* (resolved) as

an indication of the closeness of their constituent stars. 397 resolvable Nebulæ present themselves in this table, of which 12 only are within the borders of the *Via Lactea*.

Finally, a fourth tabular view was prepared, and is here-with presented (see Table, pp. 260–261), showing the distribution of all remaining objects, that is, the unresolved Nebulæ, of which 64 lie within the *Via Lactea*. 4053 objects are found in this table, but it should contain 4042 if the previous numbers are correct; the agreement of these numbers shows the sufficient accuracy of the numerical processes.

In the accompanying arrangement of the unresolved Nebulæ the horizontal lines represent the meridians distant $0^h 30^m$ of R.A. from each other, beginning at $0^h 0^m$; the vertical lines represent the circles distant 10° of N.P.D. from each other, beginning at 0° . The heavy lines inclose the *Via Lactea* and the *Nubeculæ*. The secant of the middle of each zone is given at the bottom of the Table.

Besides the zone whose average breadth of 10° here represents the *Via Lactea*, use has been made of a still broader zone, symmetrical therewith but 30° wide, and which may be supposed to include within it many objects belonging to the Gallactic System, but comparatively nearer us than the faint stars forming that band.

The following Table exhibits the general character of the distribution of the 5076 objects. The column "Area" gives the approximate relative areas of the divisions of the apparent celestial sphere for two cases; first, when the Lactean band is taken to be 10° wide; second, when it is taken 30° wide.

Distribution of Nebulæ and Clusters.

	Via Lactea 10° broad.						
	All Area.	All Objects.	Cl.	\oplus	$\oplus r$	Neb. r.	Neb.
North of V.L.	18	2787	150	8	23	262	2351
In V.L. ...	3	349	254	6	13	12	73
South of V.L.	13	1552	76	13	22	80	1356
In N.M. ...	$1\frac{1}{2}$	350	52	0	14	36	248
In n.m. ...	$\frac{1}{2}$	38	3	3	0	7	25
Sum	36	5076	535	30	72	397	4053

	Via Lactea 30° broad.						
	All Area.	All Objects.	Cl.	\oplus	$\oplus r$	Neb. r.	Neb.
North of V.L.	15	2496	20	3	12	246	2215
In V.L. ...	8	767	434	14	29	35	255
South of V.L.	11	1425	26	11	16	73	1299
In N.M. ...	$1\frac{1}{2}$	350	52	0	14	36	248
In n.m. ...	$\frac{1}{2}$	38	3	3	0	7	25
Sum	36	5076	535	31	71	397	4042

Arrangement of all objects not classified as "Cl.", "⊕", or Resolvable Nebulae in Sir John Herschel's
General Catalogue, 1864.

	h	m	h	m	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
0 0 0 30	1																					
0 30 1 0																						
1 0 1 30																						
1 30 2 0																						
2 0 2 30																						
2 30 3 0																						
3 0 3 30																						
3 30 4 0																						
4 0 4 30																						
4 30 5 0																						
5 0 5 30																						
5 30 6 0																						
6 0 6 30																						
6 30 7 0																						
7 0 7 30																						
7 30 8 0																						
8 0 8 30																						
8 30 9 0																						
9 0 9 30																						
9 30 10 0																						
10 0 10 30																						
10 30 11 0																						
11 0 11 30																						
11 30 12 0																						

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
h m																		
12 0 to 12 30	12	17	23	23	23	31	32	91	76	13	7	2	4	2				
12 30 13 0	7	1	16	11	18	36	22	22	39	45	21	7	11	26				
13 0 13 30	3	3	15	16	30	9	21	16	10	20	20	22	10	12	1			
13 30 14 0	1	3	11	23	23	29	5	4	22	12	3	8	6	5				
14 0 14 30	1	4	2	13	11	27	14	10	29	7	3	3	1	6	1			
14 30 15 0	2	2	3	9	18	13	4	3	23	4	8		1	2		1	2	
15 0 15 30	2	2	3	12	13		3	7	7	3	3	2		1	1	1		
15 30 16 0	2	2	2	5	4	2	1	7	4		1	1	1				1	
16 0 16 30	3	1	1	5	9	12	2						7	3	2		1	
16 30 17 0	2	1	3	1	2	5	3								1		1	
17 0 17 30	3	4	1	1	2		1	1	1	2	1	3	5		2			
17 30 18 0	2	2	5			1	1	3	1			9	1		4	6		1
18 0 18 30	1	1	1	1		1		1	1	1	3	1	3		3	2		
18 30 19 0				1	1	1						1			6	11		
19 0 19 30					1	1			2	1			2	2	6	6	2	
19 30 20 0			2			1	1		1	1	1	1	1	6	8	2		
20 0 20 30						2		1	1	2	1		2	8	4		5	1
20 30 21 0		1			1	3	1	2		6	1		2	8	6	3		
21 0 21 30		1						1	3	1			2	11	2	2		
21 30 22 0		2			2	1	2	1			3	7	14	11	9	7	2	
22 0 22 30					1	5	2	2			6	8	10	4	1	3		
22 30 23 0		1	1	1		9	5	14	12	2	4	9	6	10	1	4		
23 0 23 30		2	2		3	1	5	21	22	14	2	1	5	7	6	6		1
23 30 0 0		2				2		8	18	2	1		3	2	1	3		
Secant	11.5	3.9	2.4	1.7	1.4	1.2	1.1	1.0	1.0	1.0	1.0	1.1	1.2	1.4	1.7	2.4	3.9	11.5

Downloaded from <http://mnras.oxfordjournals.org/> by UCSF Library on April 8, 2015

The study of the foregoing Tables may lead to the following conclusions or suggestions:—

1. The Clusters (Cl.) are members of the *Via Lactea*, and are nearer to us than the average of its faint stars.

2. The Nebulæ resolved and unresolved lie in general without the *Via Lactea*, which is therefore essentially stellar.

3. The visible universe is composed of systems, of which the *Via Lactea*, the two *Nubeculæ*, and the Nebulæ, are the individuals, and which are themselves composed of stars (either simple, multiple, or in clusters) and of gaseous bodies of both regular and irregular outlines.

Confining our attention to the Nebulæ, we might conceive their paucity in the immediate neighbourhood of the *Via Lactea* to be partially due to the comparative glare of the intervening multitude of stars; but their persistent paucity when the limits of that band are supposed greatly increased (to $\frac{8}{36}$ of the entire celestial surface) implies that the Nebulæ are actually either fainter or scarcer, that is, less condensed, in the neighbourhood of that plane, or that the visible universe is less extended in that direction. As the gradual successive increase in the powers of our telescopes has not revealed to us many new faint nebulae in this band, we may be led to consider that these instruments have brought to view the great portion of the existing nebulae that lie apparently near the plane of the *Via Lactea*, and that this plane cuts nearly at a right angle the axis of a prolate ellipsoid, within whose surface all the visible nebulae are uniformly distributed.

From this point of view results that the *Nubeculæ* are merely nebulae accidentally near to us, and we have to inquire concerning the position of the Sun, or rather of the *Via Lactea*, with reference to the 4134 (= 2613 + 85 + 1436) other nebulae.

Let d be the distance from the Sun (S) northwards to the centre (C) of the supposed prolate ellipsoid of revolution, whose semiaxes are a and b . The volume of the ellipsoid is $2V = \frac{4}{3}\pi ab^2$; that of the section between planes through S and C, parallel to the *Via Lactea*, will be

$$V' = \frac{4}{3}\pi ab^2 \left(\frac{3}{4} - \frac{1}{4} \frac{d^2}{a^2} \right) \frac{d}{a}.$$

The volume on the south side of the Sun is therefore

$$V - V' = V \left(1 - \frac{3}{2} \frac{d}{a} \dots \dots \right);$$

that on the north side is however

$$V + V' = V \left(1 + \frac{3}{2} \frac{d}{a} \dots \dots \right).$$

Therefore, assuming an uniform distribution throughout, we have

$$\frac{V - V'}{V + V'} = \left(1 - 3 \frac{d}{a} \dots\dots\right) = \frac{1436 + 42}{2613 + 43} = \frac{5}{9} \text{ nearly,}$$

whence $\frac{d}{a} = \frac{4}{27}$.

This result is essentially dependent upon the assumption that our telescopes have made visible all the nebulæ of mean brightness within the distance $a + d$.

The ratio $\frac{d}{a}$ may be also obtained from a comparison of the apparent densities at the north and south poles of the universe; the volumes of the visual cones extending from S to these poles are in the ratio $\left(\frac{a-d}{a+d}\right)^3$ which becomes $= \frac{53}{456}$ if we examine circles of 15° radius about each pole, whence $\frac{d}{a} = \frac{1}{3}$.

Both of the above resulting values for d are to be modified by the consideration that much more powerful telescopes have been used in the northern than in the southern hemisphere, and the satisfactory solution of all questions as to the distribution of Nebulæ in space must await a new general survey of the heavens with one and the same instrument, successively stationed at different latitudes and under similar atmospheric conditions.

The preceding results will also be modified if certain hours of Right Ascension have been less carefully surveyed than others; an examination of the sweeps made with the 20-foot reflector has however failed to reveal any important omission in this respect as regards Sir John Herschel's observations.

With respect to the relative distances of the Nebulæ from us it may be remarked that, if the order of distance be in general represented by the progression—Clusters, globular Clusters, resolvable globular Clusters, resolvable Nebulæ, Nebulæ—then will the results given by Mr. Huggins on p. 383 of the *Phil. Trans.* for 1866 be represented by the assumption that light undergoes in its nature some modification in passing through immense distances of imperfectly elastic ether, as well as by the assumption that a certain proportion of nebulæ are gaseous, as distinguished from others which are aggregations of glowing solid or liquid globes. But this latter seems too plausible to be improbable, and receives sufficient confirmation from the apparent association of stellar and gaseous masses in the same Nebula. Now it may be remarked that the General Catalogue contains 34 planetary nebulæ (\odot) and 4 annular nebulæ (\odot); the former of which may be especially said to give optical signs of having a gaseous nature. These bodies follow almost identically the law of distribution given by the Clusters, for we have:—

Distribution of Planetary Nebulæ (○).

	V.L. 10° broad	V.L. 30° broad.
North of V.L.	16	9
In V.L.	9	21
South of V.L.	9	4
	34	34

Whence, in accordance with the previous views, the planetary Nebulæ may be classed with the Clusters as regards their arrangement and distance from us, and are to be considered as the gaseous globes belonging to our *Via Lactea*, which therefore retains its character as essentially a stellar Nebula, forming with the *Nubeculæ* and the 4100 ($= 262 + 12 + 80 + (2351 - 16) + (73 - 9) + (1356 - 9)$) Nebulæ, the entire visible universe.

It will perhaps be sufficient if, without advocating the correctness of the previous conclusions, we are led to undertake any rational course of systematic investigation. The questions as to the spectra of the planetary Nebulæ, the resolvability of the Nebulæ in the neighbourhood of the *Via Lactea*, and the condensation of Nebulæ around the poles of that band, seem worthy of special study.

January 1867.

On the Estimation of Star Colours. By Sidney B. Kincaid, Esq.
(Abstract.)

The author remarks that with the exception of the two isolated instances of *Sirius* and 95 *Herculis*, the latter of them due to the researches of the late Admiral Smyth and the Astronomer Royal for Scotland, no crucial example of the change of the colour of a star has been determined; although there is every reason to believe that such objects vary as well in their hues as in their apparent brilliancies. That Physical Astronomy, which has made such strides in relation to the "Variables," has done so little in the matter of sidereal chromatics is certainly not owing to any lack of interest on the part of the latter subject of inquiry, but is owing to the difficulties that beset any attempt at accurate chromatic observation. Until the publication of the late Admiral's last work, which was specially devoted to the "Colours of Double Stars," no general system for reducing such observations to permanent record in connexion with perpetual standards of comparison had been introduced; and although a great step was taken by the suggestion to use a universally recognised scale of colours as a point of reference—for which aim was given a chromic plate in the book,—coupled with the mentioned use by Mr.